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Recent developments in cassava frying operation and equipments used for gari production in Nigeria

Développements récents dans le procédé et les équipements utilisés pour la garification au Nigéria

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- Abstract -

Gari frying or garification is the most critical unit operation in the processing of cassava into gari. The quality of the final product is much dependent on garification which is a combination of simultaneous cooking and drying processes. There is the need therefore to regulate the heat intensity to the required and adequate level at each stage of the process.

The paper reviews and appraises the developments in equipments used in gari frying and these include traditional manually operated, improved manually operated and fully mechanized models. It was found that the design concept of most of the models was based on the village processing techniques. The equipments' simulated the basic principles of continuous agitation and pressing, to avoid the formation of lumps. Although most of the models investigated, performed relatively well, as regards the quality of the final product, the best results were obtained from the improved manually operated equipments.

For the rural small and medium-scale processors, which are in the majority in Nigeria and developing countries, the paper recommends the adoption of some of the improved manually operated models. It further recommends that additional work be done on the ergonomic design of these equipments.

- Résumé -

La garification, qui consiste en une cuisson et en un séchage simultanés, est l'opération la plus critique de la transformation du manioc en gari; elle influe considérablement sur la qualité du produit fini. Par conséquent, il est nécessaire de pouvoir régler l'intensité du chauffage au niveau approprié au cours de l'application du procédé.

Cet article passe en revue et évalue les innovations en matière d'équipements utilisés pour la garification que ce soient ceux utilisés au cours de la garification manuelle traditionnelle, la garification manuelle améliorée ou la garification entièrement mécanisée. Il est mis en évidence que la conception de la plupart des équipements est largement influencée par le procédé traditionnel. Les équipements proposés reposent sur le principe d'une agitation continue et d'un pressage pour éviter la formation de grumeaux. La plupart des équipements testés ont permis l'obtention de produits finis de bonne qualité, mais les meilleurs résultats ont été obtenus avec les machines proposées pour améliorer le procédé manuel traditionnel. Pour les transformateurs ruraux travaillant à petite ou moyenne échelle, qui sont la majorité au Nigéria et dans les pays en développement, l'article recommande l'adoption des équipements permettant l'amélioration des procédés manuels. Il encourage, en outre, à ce que des travaux soient poursuivis pour améliorer la forme de ces machines, en particulier pour permettre une meilleure position assise et un meilleur environnement de travail, afin de limiter les risques et d'apporter un meilleur confort pendant l'opération de garification.

Introduction

Gari is a processed fermented product from cassava and is consumed in Nigeria as well as in most countries of the West African coast and in Brazil. The preparation of gari from cassava has basically been done according to village processing tehcniques. In the past ten years a lot of research has been carried out to mechanize some aspects of the unit operations used in gari production. These include peeling and washing of the roots, grating, dewatering, fermentation, sieving, frying and cooling. Earlier designs on gari production plants did not produce the desired and acceptable cassava product for the consumers. The designers of those plants did not take into account the specifications of the existing local technology.

The most critical unit operation that determines the quality of the final product in gari production is the garification or frying operation. It has been quite difficult to mechanize this operation correctly and rightly because this operation was not well understood by many designers and manufacturers. Some had erroneously assumed garification to be the same as dehydration while others had taken it to be roasting.

This paper reviews the developments in the process of gari frying and the complimentary equipments; this includes both the improved traditional and mechanized methods.

1. The technology of gari frying

Gari frying, though a dehydrating process, is not a straightforward drying process. It is not possible to produce gari from cassava pulp by just passing heated air through it. The product from such an operation would be dried cassava pulp or granules and not gari. Garification is a simultaneous cooking and dehydrating operation. The product is first cooked with the moisture in it and then dehydrated. The heat intensity during frying affects the quality of the product. The moisture content of dewatered and sieved cassava mash is between 50 to 65% which has to be reduced to around 12% after the frying operation. In the village tehnique, the initial frying temperature is relatively low so as to avoid the formation of many lumps or caking. As the moisture content reduces and most of the small lumps developed, have been broken down by constant pressing and agitation, the heat is then increased in order to further cook and dehydrate the product. The colour and taste of gari can then be enhanced by adding a few drops of palm oil. At the end of the frying operation, the product is still hot and a little bit damp. It is then left to cool and dry in a cool dry shade until the moisture content is reduced to 12%.

The following points should be noted during frying:

a) Regulation of heat input with time during frying to avoid caking.

b) Adequate agitation and pressing to break lumps formed and to ensure uniform heat application.

c) Ensure that the final product is cooked and dehydrated.

2. Improved village methods

Traditionally, gari is fried by women in shallow earthen-ware of cast-iron pans (agabada, Nigerian Ibo) over a wood fire. Women use spatula-like paddles of wood or calabash sections to press the sieved mash against the hot surface of the frying pan and turn it vigorously to avoid caking. The operator sits sideways by the fireplace while frying. The discomfort due to heat and the sitting posture of the operator have been of concern to researchers. Thus, some innovations and improvements have been initiated and carried out in the equipment and the general set-up of the village method so as to alleviate the problems encountered by women.

2.1. UNIBADAN improved fryer

The UNIBADAN (University of Ibadan) improved gari fryer (Igbeka, 1988), is made of a fireplace oven with a chimney and a frying pan (Figure 1). The frying pan which is 200cm x 60cm x 10cm is designed to have a trapezoidal shape with its sides inclined at 60° to the horizontal. The inclination of the sides allows for gradual gravitational flow of gari down the sides of the fryer. It is made from a 4mm thick black steel sheet, which is not easily coroded and does not turn black after heating. The frying pan has an opening or chute on one side for discharging the finished product into a receiving pan. The frying pan sits on a rectangular fireplace built of clay which is 60cm high and has an opening on one side of the breath or width from where fire wood is fed into the oven, while the other width carries the chimney. There are two small ventilation openings on one side of the length. The wall thickness of the fireplace is 22.5cm and the effective volume of the heating chamber of the fireplace is 0.72m3. It can use up to 20kg of wood as source of heat. The structure is housed under a shed made of corrugated iron sheets.

The fryer is operated by two people sitting on both ends of the fireplace without ventilation. Details of the construction can be obtained in Egba (1987). Field tests amongst gari producers showed that the improved models had the following advantages over the village fryer:

a) The nuisance of smoke was totally eliminated.

b) Sweating by the operator was drastically reduced as a result of the improved fireplace.

c) The capacity and rate of frying were increased. (ex. 5kg dewatered and sieved mash took 20 min to fry as opposed to 1h).

d) Improved working environment.

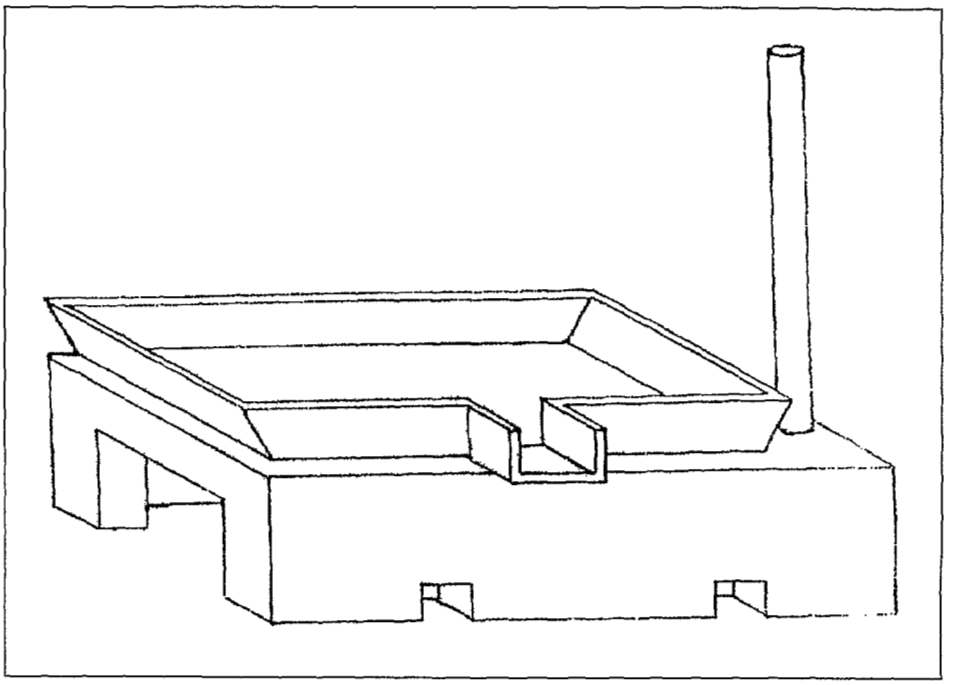

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Figure 1
Unibadan Improved Traditional Fryer

2.2. IITA model

The IITA (International Institute of Tropical Agriculture, Ibadan, Nigeria) model is a one-man operated gari fryer with an elevated fireplace oven. The frying pan is circular, made of cast iron and is smaller than the normal traditional pan in diameter but has more depth. The pan sits on a circular oven which has a chimney and can use either dense rice husk or wood shavings as fuel. A modified version (Igbeka *et al.*, 1992) of the IITA model is shown in Figure 2.

The model eliminates smoke and heat hazards from the operator. As a result of the elevated fireplace, the sitting position and comfort of the operator are enhanced. The capacity of the fryer is much higher than the usual traditional fryer.

2.3. RAIDS model

The RAIDS (Rural Agro-Industrial Development Scheme) developed by the Nigerian Federal Department of Agriculture and Rural Development is an improved fryer package for the rural processors of gari. It is similar to the UNIBADAN model and is rectangular in shape. The frying pan is made from cast iron which sits on an elevated oven fireplace with a chimney. It has outlet gates or spouts for discharging the finished products from the pan and is operated by two persons.

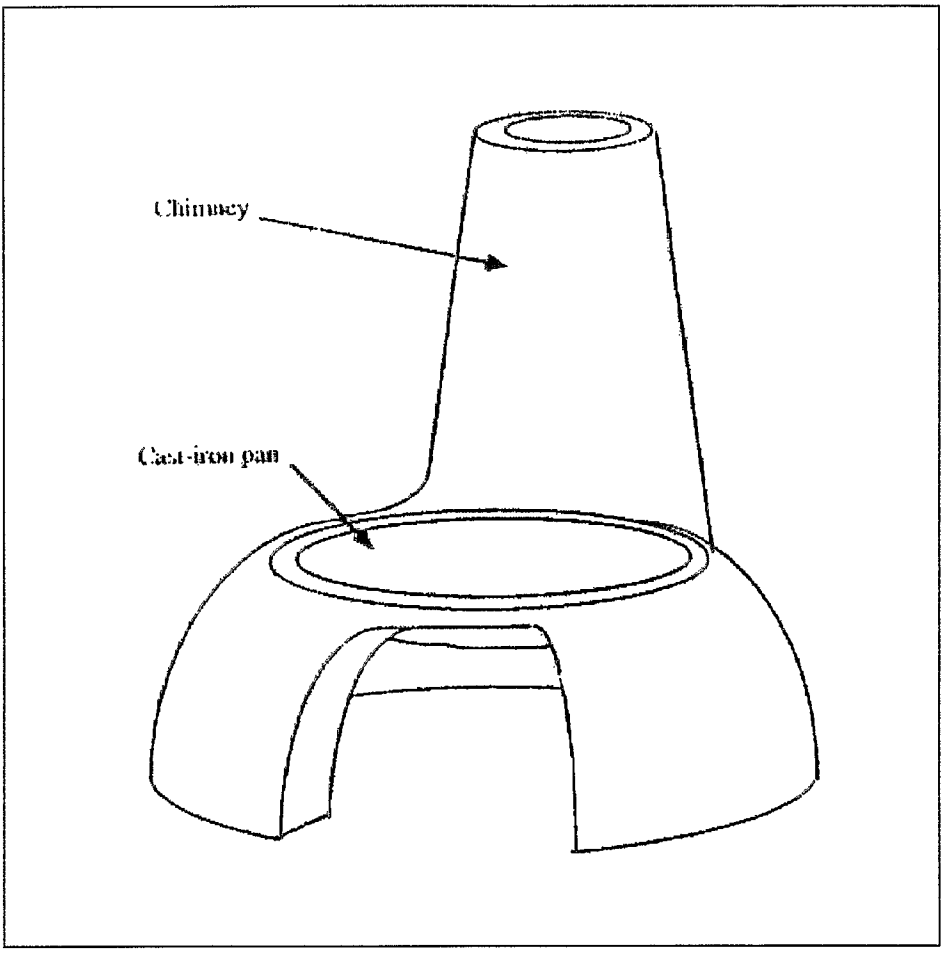

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Figure 2
Modified IITA Improved Traditionnal Fryer

The RAIDS model has been found to increase output per unit time and eliminate smoke and heat discomfort to the operators. The model produces good quality of gari.

3. Mechanized methods

There are few mechanized gari processing plants in the Nigerian market which have found to be performing well as regards the quality of gari. As a result, some new designs and improvements have been made by Nigerian engineers and manufacturers to solve the problems associated with the models already in the market.

3.1. Newell Dunford model

This was the first equipment designed jointly by the Newell Dunford Company in London and the Federal Institute of Industrial Research (FIIRO), Oshodi in Nigeria. It is a gari producing plant of which the fryer is just one of the components.

In the frying section, heat from a gas fire is controlled and regulated by thermostats at various points in the process. The fryer structure is a circular stainless steel, heated from outside with the fryers curvelinearly lined internally. The fryer containing the sieved dewatered cassava mash is rotated in such a manner that the mash granules agitate against the sides of the fryer and move along the paths of the line curves. The result of this type of heat treatment is roasting. The product obtained with this model was not very much acceptable to the consumers because it did not have the basic characteristics of gari.

3.2. Brazilian model

The Brazilian model fryer consists of a semi-circular steel plate and operates on a batch process drying. Atop the plate is a large ring gear mashed to an inner annulus which is connected to a vertical shaft with large steel paddles. A specific batch of sieved cassava mash is dropped into the circular plate and the accentric paddles shift the mass circularly to produce a dry product. An automatic gate is opened at the side of the plate and the dried product falls into a funnel by gravity.

This model, designed and manufactured in Brazil, seems to be better than the Newell Dunford model and the product obtained from it is similar to gari in Nigeria, even though it is not exactly the same. In this model, frying was not evenly spread within a given batch and the product looked more like dried cassava mash than cooked and fried gari.

3.3. Fabrico model

The Fabrico model is a simple continuous process plant and consists of a semi-circular steel plate with rotating paddles. The paddles are eccentrically located in such a manner that their motion compels the frying gari granules to move from one end of the plate to the other. Drying occurs during this period. Heat is supplied by either wood or gas-burners.

This model which was designed and manufactured by a company, FABRICO, in Nigeria, produces an end-product that is closer to gari. The product was not cooked but looked more like roasted gari. This model has been improved upon by the University of Nigeria Nsukka, and the University of Ibadan.

3.4. UNN model

The UNN (University of Nigeria, Nsukka) model was designed by Odigboh and Ahmed (1982).to faithfully simulate the village manual frying operations (Odigboh, 1985).

The equipment has a semi-circular 1.7 m long frying trough of 57cm diameter mounted at an inclination variable from 0 to 20° to the horizontal. Sixteen spring-loaded paddles are attached to a 1.75m long shaft also mounted axially in such a way as to locate the paddles inside and in permenant contact with the trough as shown in Figure 3. The paddles overlap and are angled relative to the axis of the trough to act as a sort of conveyor. They are driven by an electric motor through several speed reducers and linkage arrangements. As the gang of paddles oscillate through 180° at 40 reversals per minute sieved cassava mash is automatically metered into the trough, once in a cycle of the to and fro motion. Swinging to one direction, the paddles press the mash against the hot surface of the trough while in the opposite direction, they scrape, stir and move it slightly forward to the exit end of the trough.

By appropriate adjustments of the trough inclination, the quantity of mash metered and the heating rate, the fryer operates automatically to produce a continuous flow of well fried gari at 15% moisture content. An average through-put of 66kg of gari per hour has been reported for this equipment. Through-put of the manually operated version (Figure 4) is 20 to 45kg of gari per hour.

3.5. UNIBADAN model

The UNIBADAN model was designed and manufactured in the University of Ibadan (Igbeka and Akinbolade, 1986). It is a continuous flow fryer which is an improvement and modification of the UNN model, hence a modified version of the Fabrico model.

The basic differences are in the feeding device, the heat source and the arrangement of the paddles. The UNIBADAN model is made up of a fryer plate, feeding hopper, power transmission devices, shaft with paddles, pulverizers and an oven on which the fryer sits (Figure 5). This model is still in its prototype stage and has not been commercialized.

The fryer plate, like in the UNN model, is a semi-circular trough open at the top and both ends. It is inclined at an angle of between 5 and 18° with a length of 2.44 m and diameter 0.67m. The hopper contains a metering device which is one of the basic innovations in the design. The metering device is connected to the central shaft through a belt and pulley system and the rate of metering is very crucial to the quality of the final product. Another innovation in this model are in the paddles. Instead of just paddles, as in the UNN model, the central shaft has 28 paddles and pulverizers arranged in such a way that they have a conveyor effect at the same

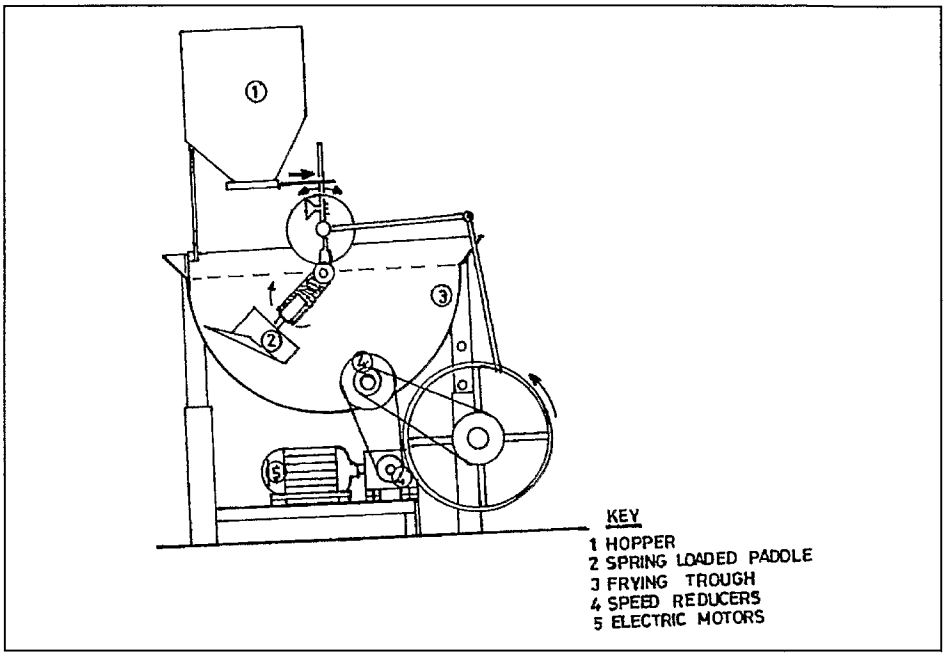

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Figure 3
UNN Mechanized Fryer

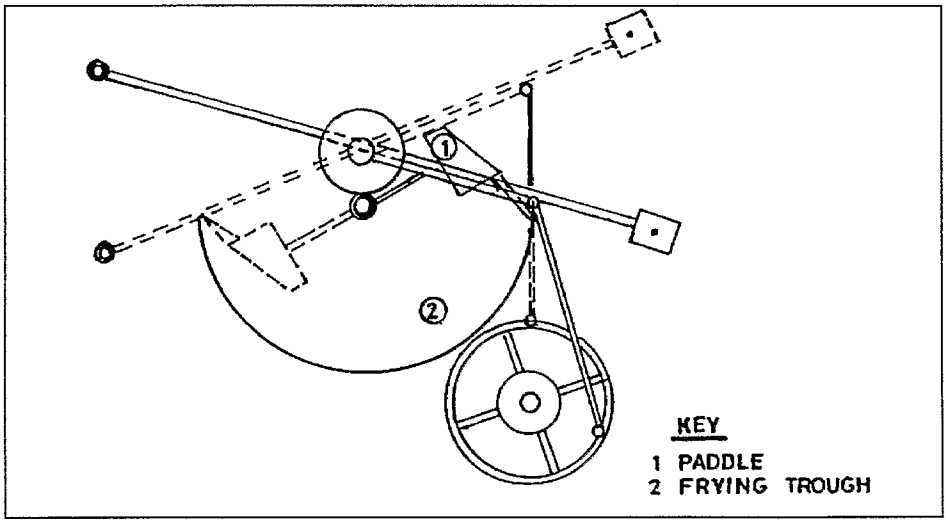

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Figure 4
UNN Mechanized Manual Fryer

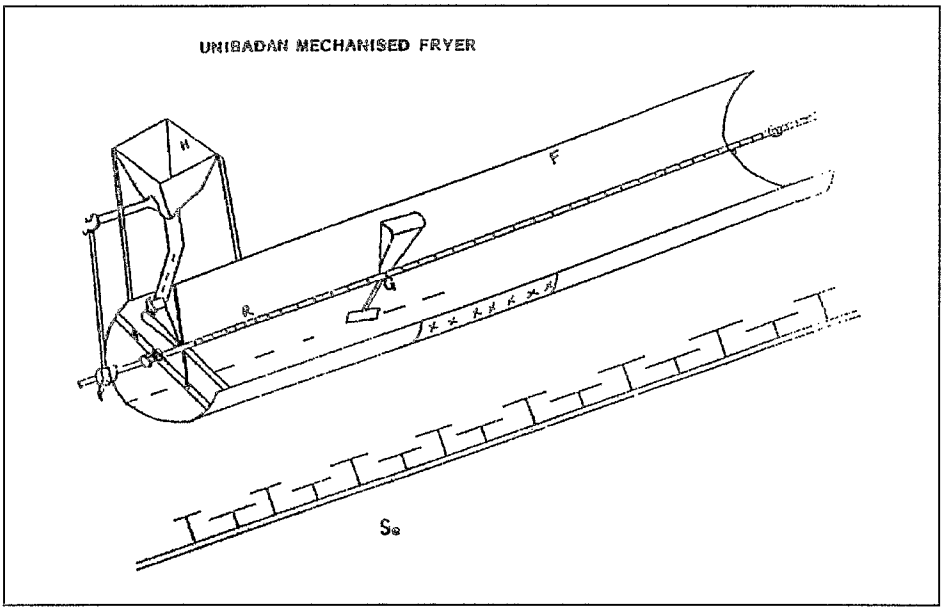

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Figure 5
Sketch of the Fryer Showinf the Hopper and Paddle attachment

time as they press scoop and agitate (figure 6). The pulverizers press the sieved cassava mash against the hot pan surface while the paddles scoop and agitate it. The oven is built with red oven-dry bricks and has air vents at specific points and uses wood or coal as fuel. The vent openings can be reduced or increased according to the heat requirements. Power supply to the fryer could be either a petrol engine or fire wood.

Field tests using this model showed that the final product was acceptable to the public. At 15 rmp, the capacity was 80kg/hr of finished product.

Discussion and conclusion

Gari frying is an arduous and intricate operation which is not a straightforward frying operation but that needs good understanding of the factors that affect the quality of the final product.

The best quality gari is obtained by the village technique but it is time-consuming, uncomfortable and lends itself to health hazard for the operator. Developments in the processes and equipment have been more on the accurate simulation of the village technique. Therefore, in developing any mechanized gari fryer the following features have to be considered as basic requirements:

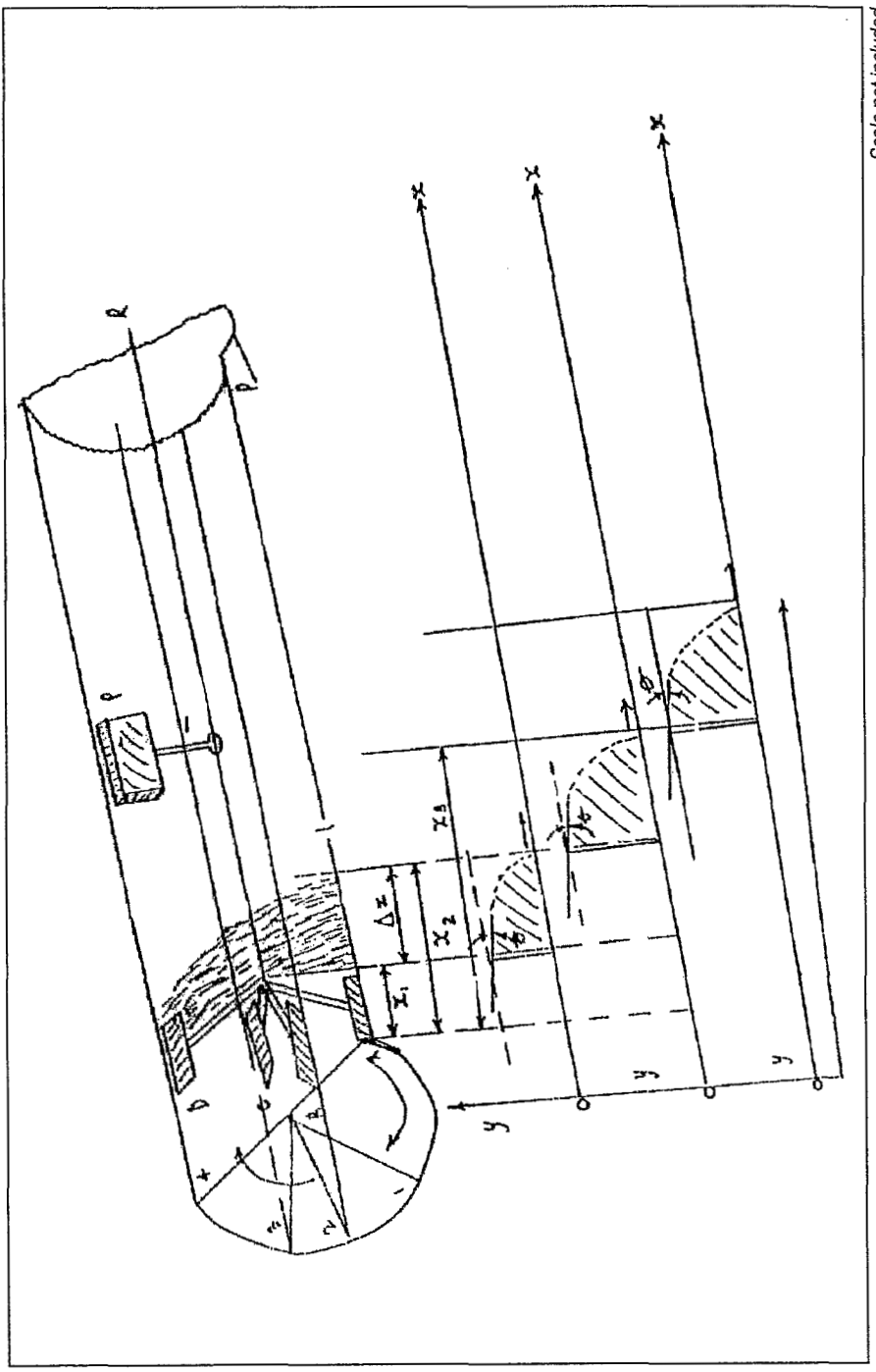

Figure 6
Paddle operation and mode of grain travel in Unibadan model

1. A continuous process operation leading to mass production of moderate capacity.
2. A regulated temperature mechanism which ensures simultaneous cooking and dehydration, without roasting, to a desired moisture content after a specific period.
3. A mechanism that provides both stirring and lump breaking actions so that uniform cooking and dehydration in the entire mass is ensured and the desired texture produced.
4. An arrangement of paddles so as to produce a conveyor effect which will give the product a forward movement during the process.

Mechanized fryers are not within the reach of the rural farmers who are the main producers of gari in all the gari-producing countries including Nigeria. Commercialised models are for large-scale producers while the developed prototypes by the universities which could have been within the reach of the small-scale farmers are not yet in the market.

Efforts should be made to mechanize the garification operation for large-scale processing without lossing sight of improving the village method. The improvements in garification should be in the areas of ergonomics (sitting position, comfortable work environments and health hazards). Igbeka (1993), recently carried out studies on the ergonomics of Nigerian women in gari frying. The factors investigated were the comfort, fatigue and arm-reach of the operators as they affected the efficiency of operating three types of traditional gari fryers. It was found that the sitting posture and excessive heat were the two main factors that affected the arm-reach and comfort of the operator, respectively. Improved designs that reduced heat and changed the sitting posture were found to increase efficiency.

In conclusion, although most of the equipments reviewed in this paper performed relatively well, the best results were obtained from the improved village techniques. The adoption and adaptation of any of these techniques (improved traditional or mechanized) will depend on the socio-economic status of the users. The improved village technique is recommended for the rural small- and medium-scale gari processors.

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